CLAIMS

1. A rehabilitation device comprising:

a frame;

an actuator that includes a movement mechanism capable of applying a force that interacts with a motion of a patient's limb in a volume of at least 30 cm in diameter, in at least three degrees of freedom of motion of the actuator and capable of preventing substantial motion in any point in any direction in said volume;

a joint interconnecting said frame and said actuator and allowing multiple different relative placements of said movement mechanism on said frame, such that said volume moves relative to said frame.

2. A device according to claim 1, wherein said motion mechanism has different motion limitations in different spatial direction and wherein said multiple relative placements include changing an orientation of said mechanism.

3. A device according to claim 1, wherein said joint comprises a linear joint.

4. A device according to claim 1, wherein said joint comprises a swiveling joint.

5. A device according to claim 1, wherein said frame is curved.

6. A device according to claim 1, wherein said joint is motorized.

7. A device according to claim 6, comprising a controller that controls said joint according to an exercise stored in said controller to be performed.

8. A device according to claim 1, comprising at least one sensor that reports a position of said joint.

9. A method of setting up a rehabilitation system including an actuator that includes a movement mechanism capable of applying a force that interacts with a motion of a patient's limb in a volume of at least 30 cm in diameter, in at least three degrees of freedom of motion

of the actuator and capable of preventing substantial motion in any point in any direction in said volume, comprising:

determining a rehabilitation exercise to be performed;

selecting a desired position for said motion control mechanism for said exercise; and

adjusting a position of the mechanism on a frame according to said desired position.

10. A method according to claim 9, comprising automatically adjusting said position.

11. A method according to claim 9, comprising automatically reporting to a user said desired position.

12. A rehabilitation device, comprising:

a joint having freedom of motion in Phi (rotation) and Theta (elevation) spherical angles, said freedom allowing positioning of said joint in substantially any angular position within a range of at least 30 degrees in each angular direction.

a substantially rigid radial extension attached to said joint and adapted for movement with a limb of a person at at least one point thereof; and

a controller adapted to control motion of said joint and thereby motion of said radial extension.

13. A device according to claim 12, wherein said radial extension is balanced such that said point remains stable if no force is applied and moves if force is applied by said person.

14. A device according to claim 13, wherein said balancing can be varied to match a weight of an attachment selectively attached to said extension.

15. A device according to claim 13, wherein said balancing can be varied by said controller along a path of motion to match a change in moment on said point.

16. A device according to claim 13, wherein said balancing can be set to provide a neutral buoyancy to said limb.

17. A device according to claim 12, wherein said joint is a ball joint.

18. A device according to claim 12, wherein said joint comprises two orthogonal hinges with a common center of rotation.

19. A device according to claim 12, wherein said controller comprises a mechanical controller.

20. A device according to claim 12, wherein said controller comprises an electrical controller.

21. A device according to claim 12, comprising at least one brake adapted to selectively resist said freedom motion.

22. A device according to claim 21, wherein said brake is continuously controlled by said controller.

23. A device according to claim 21, wherein said brake is uni-directional in only one of said Phi and Theta directions.

24. A device according to claim 21, wherein said brake is operative in both said Phi and said Theta directions.

25. A device according to claim 12, comprising at least one motor adapted to move said joint.

26. A device according to claim 25, wherein said motor is adapted to apply at least 10 Kg of force at said point.

27. A device according to claim 25, wherein said motor is continuously controlled by said controller.

28. A device according to claim 25, wherein said motor cannot be back-driven by said extension.

29. A device according to claim 12, comprising at least one resilient element adapted to provide resilient compliance when said person moves said point in a trajectory other than a trajectory for which motion is controlled to move by said controller.

30. A device according to claim 29, wherein said controller sets a degree of said resilient compliance.

31. A device according to claim 12, wherein said element is extendible.

32. A device according to claim 12, wherein element includes a conduit for electrical power.

33. A device according to claim 12, including at least one position sensor which reports on a angular position of said joint.

34. A device according to claim 12, including at least one force sensor which reports on a force applied to said joint.

35. A device according to claim 12, wherein said controller is configured to control said motion and provide at least one of assisting motion by said patient limb, resisting motion by said patient limb, guiding motion by said patient limb, nudging said patient limb to move and moving said patient limb.

36. A device according to claim 35, wherein said controllers stores thereon a plurality of different rehabilitation exercises.

37. A balanced rehabilitation device, comprising

an actuator that includes a movement mechanism capable of applying a force that interacts with a motion of a patient's limb in a volume of at least 30 cm in diameter, in at least three degrees of freedom of motion of the actuator and capable of preventing substantial motion in any point in any direction in said volume; and

at least one weight that balances said actuator such that no force is required to maintain

said actuator in space.

38. A method of rehabilitation, comprising:

assisting motion in space of a patient along a trajectory, using an actuator;

providing resistance to motion by said patient away from said trajectory, said resistance including compliance in a direction away from said trajectory,

wherein said compliance is achieved mechanically without an electro-mechanical feedback loop.

39. A method according to claim 38, wherein said compliance is provided by braking.

40. A method according to claim 38, wherein said compliance is provided by at least one resilient element.

41. A method according to claim 38, comprising tracking said motion of the patient with said compliance.

42. A method according to claim 38, wherein a different force of resistance is provided at different points in space along the motion.

43. A method according to claim 38, wherein a different force of resistance is provided at different direction at a same point in space.

44. A method according to claim 38, wherein said compliance is at least 1 cm.

45. A rehabilitation device comprising:

a lever adapted to move together with a portion of a patient's body;

a motor, operatively connected to said lever in a manner which prevents back-driving of the motor by said lever, said motor being operative to move the lever; and

a spring coupled to said lever and providing resilience to said motion.

46. A device according to claim 45, wherein said spring provides said resilience only when said lever is moved different from motion caused by the motor.

47. A device according to claim 45, wherein attempted back-driving of said motor applies force to said spring.

48. A device according to claim 45, wherein said spring has a controllable pre-load.

49. A device according to claim 45, comprising a damping element in parallel with said spring.

50. A rehabilitation device comprising:

a lever adapted to move together with a portion of a patient's body;

a motor, operatively connected to said lever to move the lever;

a slot guiding motion of said lever; and

a spring coupled to said lever and providing resilience to said motion.

51. A device according to claim 50, wherein said spring is mounted on said slot.

52. A multi-axis resilient element for rehabilitation, comprising:

a first set of at least one joint adapted to allow motion in spherical coordinates of a radially extending lever;

a second set of at least one joint adapted to allow motion in spherical coordinates of said first set;

a resilient element having a compression associated with motion of said lever thereby compliance to motion in said second set.

53. An element according to claim 52, wherein said resilient element has a settable pre-load.

54. A rehabilitation device comprising:

a lever adapted to move together with a portion of a patient's body;

a motor, operatively connected to said lever to move the lever; and

a spring coupled to said lever and providing resilience to said motion,

wherein said spring has a settable compliance.

55. A device according to claim 54, wherein said compliance is set by a controller.

56. A device according to claim 55, wherein said setting is continuous.

57. A device according to claim 54, wherein said spring is a flat spring having a settable effective length.

58. A telescoping mechanism comprising:

at least three telescoping sections, including a central section and two end sections;

an actuating mechanism that extends said central section;

a first rack and pinion mechanism that couples motion of one of said ends and of said central portion;

a second rack and pinion mechanism that couples motion of the other one of said ends and of said central portion; and

a belt operatively linking the two rack and pinion mechanisms.

59. A portable rehabilitation device comprising:

a base for stabilization of the device to a surface or object; and

an actuator that includes a movement mechanism capable of applying a force that interacts with a motion of a patient's limb in a volume of at least 30 cm in diameter, in at least three degrees of freedom of motion of the actuator and capable of preventing substantial motion in any point in any direction in said volume,

wherein said device has two configurations:

a first configuration suitable for practicing rehabilitation; and

a second configuration suitable for storage, and wherein

said device is adapted to pass between said configurations manually, by a layman.

60. A device according to claim 59, wherein said device is taken apart for said second configuration.

61. A device according to claim 60, wherein said device comprises at least one quick-connection.

62. A device according to claim 59, wherein said device folds down.

63. A device according to claim 59, wherein said device folds flat to fit in a car trunk.

64. A device according to claim 59, wherein said device weighs less than 30 Kg.

65. A device according to claim 59, wherein said device is wheeled

66. A rehabilitation device, comprising:

a lever adapted to move together with a portion of a patient's body;

at least one motor coupled to said lever adapted to interact with a motion of said lever; and

at least one separable element interconnecting said motor and said lever and adapted to decouple at least a portion of said lever from said motor is a predetermined force on the element is exceeded.

67. A device according to claim 66, wherein said element comprises a tearing pin.

68. A device according to claim 66, wherein said element comprises a separable joint.

69. A device according to claim 66, wherein said element is connected between a body of said lever and an attachment mounted on said lever.

70. A rehabilitation device, comprising:

a lever adapted to move together with a portion of a patient's body;

at least one motor coupled to said lever adapted to interact with a motion of said lever;

at least one resilient element interconnecting said motor and said portion; and

a controller adapted to identify a safety problem and stop said motor upon said identifying, said resilient element preventing such stopping from being immediate.

71. A device according to claim 70, wherein said device comprises an actuator that includes a movement mechanism capable of applying a force to said lever which lever interacts

with a motion of a patient's limb in a volume of at least 30 cm in diameter, in at least three degrees of freedom of motion of the lever.

72. A deice according to claim 70, wherein said controller identifies said safety problem by detecting a shout by said patient.

73. A deice according to claim 70, wherein said controller identifies said safety problem by calculating at least one position of a point of the body of said patient and comparing the result of the calculation to one or more allowed value.

74. A rehabilitation docking station comprising:

an actuator that includes a movement mechanism capable of applying a force that interacts with a motion of a patient's limb in a volume of at least 30 cm in diameter, in at least three degrees of freedom of motion of the actuator and capable of preventing substantial motion in any point in any direction in said volume;

at least one actuator adapted to assist in rehabilitation by; and

a docking port adapted for locking to a patient carrier.

75. A station according to claim 74, wherein said port is adapted to engage a wheelchair.

76. A station according to claim 74, wherein said port is adapted to engage a bed.

77. A station according to claim 74, wherein said station is mobile.

78. A station according to claim 74, wherein said station includes at least one port for attachment of a second actuator thereto.